

correspondence of the foregoing results with those obtained by Vernon in echinoderms.

The difference between different members of the same family must be in part attributed to the potential difference of the cells from which they are respectively developed. Whether the reducing division of the germinal cells is qualitative as well as quantitative is an open question, but there is reason to think that the life-history of these cells previous to conjugation may give opportunity for environmental variation like that of the Protozoa.

Turning now to the subject of "germinal variation," the author points out that the existence of such environmental variation in the germ-cells, apart from reducing division, together with the physiological differences dependent on diverse conditions of vigour and maturity, may be expected in most cases to preclude the new individual from assuming an exactly intermediate position between its parents. When the male and female germ-cells unite, a series of contests takes place between groups of vital units, the issue being decided by their respective qualities, individuality or character.

When different varieties or species are intercrossed, the effects may differ not only in degree but also in kind from those of ordinary cross-fertilisation. The following are some of the results that have been obtained experimentally from such intercrossing:—

(1) The offspring may be almost exactly intermediate between the parents.

(2) The offspring may resemble one of the parents and not the other. This is often the case when wild animals are crossed with tame varieties of the same species. (It must, however, be remembered that the resemblance may be only superficial, as was clearly the case in the experiments with half-wild rabbits cited above.)

(3) Some of the offspring may resemble one parent, some the other. (This seems especially likely to occur if one or both of the parents is a sport. Standfuss's results with insects are in accord with this.)

(4) The offspring may combine, almost unimpaired, the more striking characters of both breeds. This has been seen in both pigeons and rabbits.

(5) New or unexpected characters may appear in the progeny. Three out of four of a litter of cross-bred rabbits developed a habit of "spinning."

(6) When half-breeds are crossed, the offspring tend to be extremely variable. Evidence of this is plentiful both in animals and plants.

(7) Sometimes the offspring, instead of resembling the parents, resemble former ancestors. Prof. Ewart mated a cross between an "archangel" and an "owl" pigeon with a white fantail. The issue was a bird with a striking resemblance to the ancestral "blue-rock." (Analogous results have been several times obtained in the case of insects.)

Prof. Ewart's paper is interesting and suggestive to a high degree. It would be hard to overestimate the value of the experiments which he is conducting with so much care and judgment in his well-selected menagerie at Penycuik.

F. A. D.

RUST-FUNGUS.

PROF. MARSHALL WARD'S investigations into the relations between host and parasite in the case of the Bromegrasses and their rust-fungus are bringing to light some interesting facts which have important bearings on the long-vexed questions of wheat-rust and the rust problem generally, which, as is now well known, have passed into an acute stage of late, principally owing to Eriksson's enunciation of his belief that the fungus can be transmitted in an invisible form *viâ* the seed.

In addition to testing this mycoplasma hypothesis of Eriksson's, the researches undertaken by Prof. Marshall Ward are also directed to put to the proof the questions of degrees of specialised parasitism raised during the last decade by the researches of Plowright, Kleebahn, Eriksson, Magnus, Fischer, and others, and more especially, to see if any deeper insight can be obtained into the causes of epidemics and the relative predisposition or immunity of certain plants to attack.

In a paper read to the Cambridge Philosophical Society on January 20, 1902, Prof. Ward gave a summary of his results with more than eighteen hundred infection experiments, made

on twenty-two species and varieties of *Bromus* with the Uredospores of *Puccinia dispersa* (Erikss.), the brown-rust of these grasses. These results show clearly that, other conditions being the same, the infection of a given species of *Bromus*—say *B. mollis*—by the Uredospores of the *Puccinia* depends on the origin of the spores, that is to say, on the circumstances of nutrition and breeding generally to which they have been hitherto accustomed. For instance, if the spores are reared on *B. mollis*, they infect another plant of *B. mollis* readily; but if they are reared on *B. sterilis*, they refuse to infect *B. mollis*, though they will readily infect another plant of *B. sterilis*.

But, in addition to the infective capacity of the spores conditioned by their past history, there is the question of the predisposition or immunity of the host. For instance, it is easy to infect *Bromus mollis* with spores from *B. mollis*, but far less easy to infect *B. racemosus* with such spores, and practically impossible to successfully infect *B. sterilis*. Part of Prof. Marshall Ward's work goes to prove that the immunity of given species of *Bromus* is not due to anatomical peculiarities, such as the number and size of the stomata, hairs, the volume of chlorophyll tissue and so forth, but to some substances or conditions in the living cells which escape microscopic investigation. In other words, the inquiry is being pushed into the domain of enzyme reactions, anti-toxins and so forth.

In a forthcoming paper it will also be shown that the external conditions of germination of the spores, and of infection by way of the stomata, require far more attention than they have yet received.

In a paper read to the Royal Society on February 20 last, another aspect of the investigation was opened up, namely, the possibility of obtaining pure cultures of these Uredines, a method which applies to other parasitic fungi as well.

In order to obtain more decisive answers to such questions as—Are any of the results obtained on plants in the open, or merely covered with bell-jars and so forth, due to spores accidentally introduced, or to mycelium, &c., already in the plant? a number of infections were made on seedlings germinated and grown antiseptically in tubes as follows:—

Clean picked seeds were placed singly, by means of forceps, on filter paper at the bottom of Petri-dishes properly sterilised by heat. When these had germinated, and observation showed that the whole series was free of moulds or other signs of contamination, the seedlings were removed by means of sterile forceps and transplanted singly into sterilised tubes of various kinds as described below, and the further growth allowed to proceed in the light under conditions varied as will be seen.

Prof. Ward had already shown that seedlings will continue to grow in such tubes, but, as we have seen, in the cases previously described he had no guarantee that the seedlings introduced into the culture-tubes did not already carry on their leaves wind-borne or otherwise transmitted spores.

In the case of these seedlings germinated from clean "seed" in sterile dishes and tubes, it is obvious that the only chance of infection depends on spores attached to the "seed" or on mycelium in the seed.

Experiments with seed gathered even from badly rusted plants and germinated as above have never given rusted seedlings, although other experiments have shown that the germ-tubes of attached spores can infect seedlings when the plumule is only 3–5 mm. high. Nor has Prof. Ward ever been able to discover any trace of mycelium in the seeds.

But if the "seed" of the *Bromus* is sterilised before germination—as can be done by steeping in various antiseptics, or by heating to 60–70° C.—it is found that pure cultures of the *Brome* may be obtained in the tubes, and it is then only necessary to infect such a clean seedling with the spores of the parasite to obtain a pure culture of the latter.

Preliminary experiments soon showed that the *Brome* seedlings thus raised from seeds treated antiseptically, and protected from the first by glass, may be grown for weeks and even for a couple of months in such tubes under proper precautions, and Prof. Ward set himself the task of ascertaining how such cultures would behave in infection experiments.

In the following experiment upright tubes of the kind known to chemists as "drying towers" were prepared as in the diagram (Fig. 1), so that by means of an aspirator attached to the tubing at G, a continuous current of damp air could be slowly drawn through the whole series, aerating the roots of the seedlings R, which burrowed into the cotton-wool B, day and night. The tubes were charged each with one seedling,

grown from seeds heated to 65° C., and forty-eight hours after germination had begun and the latter allowed to grow in the light on a table outside the laboratory. The tubes were charged on June 14, and on June 19, when the first green leaf was well developed, the latter was infected at a definite spot with spores

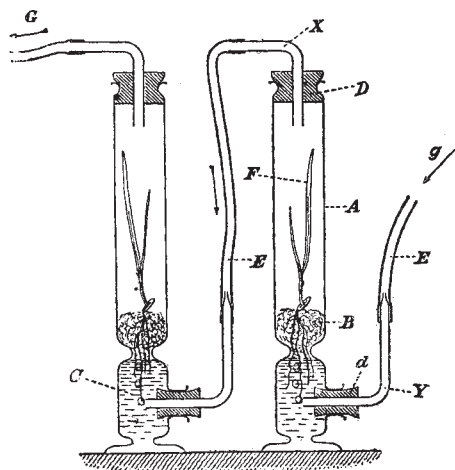


FIG. 1.

Diagram showing arrangement of tubes for pure cultures of grass seedlings—see text—here shown connected up for aëration. Reduced.

A = glass jar. B = cotton-wool saturated with liquid. C = liquid reservoir containing nutritive culture solution, through which air bubbles pass. D and d = caoutchouc stoppers pierced by glass tubing. EE = caoutchouc tubing. F = seedling with its roots in B and its leaves in air. G and g = arrows showing direction of air current. x and y = glass tubes.

—proved to be capable of vigorously germinating by cultures in hanging drops—and the whole series linked up and aërated. The growth of these seedlings in the moist air-current was very satisfactory, the plants having a deep rich green colour, though the leaves were short, and the results, as shown in the following table, were very instructive.

In this series the liquid employed was the normal Knop's mineral solution (+), so well known as used in water-cultures. The tubes were charged with this before sterilisation, enough being put in to wet the cotton-wool plug (B) and fill the reservoir (C), the side-tube y being fused at its pointed end during sterilising.

Since each tube is linked to its neighbour with clean flexible tubing, and the air bubbles through the liquid in the reservoir (c) and has to pass the cotton-wool plug (B) before reaching the leaves (F) in the air above, there can be no question of infection from outside, and the results also show that infection only occurs exactly where the spores are placed on the leaf in each case.

The spores employed were carefully tested as regards their germinating power, and, as the table shows, the results in the closed tubes fully bear out previous experience. In the aspirated tubes, however, the second pair of seedlings of *B. mollis* (No. 712) gave negative results, inasmuch as only flecks, and not pustules bearing spores, were developed. In the closed tubes, however—see below—the positive results, especially on *B. velutinus* and *B. secalinus*, were excellent, and subsequent examination showed that the spores germinated well and were capable of infecting other seedlings.

In order to test further the behaviour in mineral solutions, Prof. Ward prepared, as the table shows, several series in closed tubes, Nos. 713, which served as a parallel series to Nos. 711 and 712, but without aëration.

In No. 713 the sterile seedlings were raised antiseptically as before, but the roots merely penetrated cotton-wool saturated with Knop's solution, and held by the constriction over the bulb filled with the same, no air being drawn through. The growth was excellent, and the results very conclusive, as the table shows.

The seedlings were allowed two days at 22–20° C. in the laboratory and then put out side by side with 711 and 712 in full sun during the middle of the day, and after two days' further growth were infected.

By the tenth day the thin leaf was well developed, and the first pustule was seen on *B. mollis* and *B. secalinus* on the eighth day after infection.

The growth of pustules was excellent on *B. velutinus* and *B. secalinus* especially.

This experiment is interesting, not only as showing that plants can be grown and infected successfully in these closed water-cultures, but especially as showing the contrast between the aërated and non-aërated tubes, for, since the infected

Experiments in Aërated and in Closed Tubes. Selected and Sterilised Seeds and Clean Seedlings. Infected when one week old. Roots in Knop's Solution.

Expt. No.	Date.	Host.	Origin of spores.	Treatment.	Results.	Period of incubation.	Period of experiment.	Remarks.
711	June 19	<i>B. sterilis</i> ...	<i>B. mollis</i>	Aërated continuously	—		21 days	
"	"	<i>B. mollis</i> ...	"	" "	+	12 days	"	
"	"	"	"	" "	+	16 "	"	
712	"	<i>B. sterilis</i> ...	"	" "	—		"	
"	"	"	"	" "	—		"	
"	"	<i>B. mollis</i> ...	"	" "	?		"	Flecks developed, but no spores formed.
"	"	"	"	" "	?		"	Flecks developed, but no spores formed.
713	"	"	"	Closed tubes ...	+	8 "	"	
"	"	"	"	" "	+	12 "	"	
"	"	<i>B. sterilis</i> ...	"	" "	—		"	
"	"	"	"	" "	—		"	
"	"	<i>B. velutinus</i> ...	"	" "	+	10 "	"	Very fine growth of sporiferous pustules.
"	"	<i>B. maximus</i>	"	" "	—		"	
"	"	<i>B. madritensis</i>	"	" "	—		"	
"	"	<i>B. commutatus</i>	"	" "	+	10 "	"	
"	"	<i>B. arvensis</i> ...	"	" "	—		"	
"	"	<i>B. secalinus</i> ...	"	" "	+	8 "	"	Very fine pustules.
"	"	<i>B. interruptus</i>	"	" "	+	10 "	"	
"	"	<i>B. racemosus</i> ...	"	" "	+	11 "	"	

seedlings were selected in each case from the same Petri-dish cultures, we must assume that the difference in rate of development was due to the difference of ventilation, and perhaps conclude that this interferes with the success of the parasite, as measured by the somewhat longer incubation period. It is remarkable how dwarfed the continuously aerated plants are, compared with those in closed tubes, owing to the elongation of the leaves of the latter.

It is clear, therefore, that pure cultures of Uredospores can be obtained by this method, and it is equally clear that we can also obtain pure cultures of the host-plants, and since we can do this, there is no reason why the infection of Uredineæ should not be conducted as rigorously and exactly as that of bacteria.

As a matter of fact, Prof. Ward has succeeded in proving that it can, though of course the length of time occupied in a large series of cultures and infections will prove troublesome, and it remains to be seen whether we can get such plants to flower (see Fig. 2).

A number of isolated tube-cultures were made with spores from *B. sterilis*, *B. mollis* and *B. secalinus*, and arranged similarly, and confirmatory results obtained. Moreover, Prof. Ward was able in several cases to transfer successfully spores from these pure tube-cultures to other tubes of pure cultures of seedlings, and to prove that the spores raised under strictly antiseptic conditions are capable of germination and infection.

At the same time, it was noteworthy that in several cases the antiseptically raised spores were not always successful in infecting the seedlings, and it remains for further investigation to determine whether this was due to the conditions of culture of the fungus or the host, or both.



FIG. 2.—Pure culture of *Puccinia dispersa* on *Bromus velutinus*. The "seed" of the grass, antiseptically sterilised as regards fungus spores by heating to 65° C., was germinated in the sterile tube and infected on the first leaf with spores developed on *Bromus mollis*. The infection was successful, and pustules of spores have appeared only on the area inoculated.

sider the needs of education, and take such steps as may seem desirable, after consultation with the Board of Education, to aid or supply education other than elementary."

THE following teachers have been appointed by the Senate of the University of London, in connection with the grant of 10,000*l.* a year recently voted to the University by the London County Council in aid of the work of the faculties of arts, science, engineering and economics:—Prof. Ramsay, F.R.S., teacher of chemistry, at University College; Prof. Capper, teacher of mechanical engineering, at King's College; Prof. Unwin, F.R.S., teacher of civil and mechanical engineering, at the Central Technical College.

AN anatomical museum, endowed in memory of the late Prof. A. Hughes, was formally opened at the South Wales and Monmouthshire University College on Saturday. Prof. Hughes,

¹ I.e., of course so far as fungi are concerned, the antiseptic treatment adopted does not always exclude harmless bacteria.

who died of enteric fever contracted in South Africa, was the first occupant of the chair of anatomy at the College, and when he left to take a similar position at King's College, London, he gave 350*l.* with which to purchase the nucleus of the anatomical museum. To his memory and in recognition of his special services to medical education in Wales, it was decided to endow the museum permanently, and a fund was opened, towards which 1775*l.* has been subscribed. Of this amount 120*l.* has been set apart for the foundation of an Alfred Hughes medal, to be awarded annually in the subject of anatomy.

A VERY creditable display of pieces of simple scientific apparatus was to be seen in connection with the annual exhibition, at the Examination Hall on the Thames Embankment, of specimens of work by the pupils and teachers in the schools of the London School Board, which was opened on June 18 by Lord Reay, chairman of the Board. Compared with the exhibition of November last, which was reported in NATURE (No. 1671), a marked improvement has to be recorded. There were three times the number of exhibits, and the general standard of excellence was much higher. Many of the defects of the last exhibition were remedied in that of this year. More attention was given to the different branches of physics, and in place of the three more or less unsatisfactory models representing the teaching of physiography, which were all that we could find last time, ten times as many better pieces of apparatus were included, among which a good model of Foucault's pendulum, an astronomical telescope and a relief map of Sydenham—the last named by a couple of boys of eleven and thirteen years of age—deserve special mention. The chemical section provided abundant evidence of the influence of Prof. Armstrong on the teachers of this subject. It was clear from the exhibits in this department that every effort is being made to develop the child's intelligence by encouraging him to discover facts for himself. Though more attention was given to nature-study than was the case last year, there is still plenty of room for development in this direction. The undesirable plan of mixing up the work of teachers and taught was followed again, but it is to be hoped that the committee of management may be persuaded, before holding another exhibition, of the difficulty experienced by the visitor in knowing, without consulting a bulky catalogue, when an exhibit is the work of a pupil and when that of the instructor. It is impossible in this place to describe the exhibits in detail, but a good Wimshurst machine constructed by a boy of fourteen was an excellent instance of the trouble a youngster will take when once he has been interested in the subject of study.

SCIENTIFIC SERIALS.

American Journal of Science, June.—Fossil faunas and their use in correlating geological formations, by Henry S. Williams. It is shown that the plan usually followed of classifying geological formations in time by means of a comparison of one predominant fossil is wanting in accuracy. Very many single species, the range of which has been established by thorough study of the successive formations in which they occur, range through a third, and often a half, of one of the standard geological systems. A second reason for not resting implicit confidence on this method of correlation is the frequently observed fact that parts of the geological column of different sections, which upon satisfactory stratigraphic grounds are known to be stratigraphically equivalent, contain different fossils.—Studies of the Eocene mammalia in the Marsh collection, Peabody Museum, by J. L. Wortman. The present instalment of this series contains detailed descriptions of *Sinopa rapax* and *Sinopa agilis*.—The transmission of sound through solid walls, by F. L. Tufts. The rigidity of the material was found to be the main factor in determining the intensity of the sound transmitted from the air on one side to the air on the other, the only other factor possessing any influence being the mass.—A new gauge for the measurement of small pressures, by E. W. Morley and C. F. Brush. A description of a form of differential mercury pressure gauge resembling in principle that recently described by Lord Rayleigh. Two modes of reading are given; in the second method a reading can be taken in ten seconds. With suitably mounted instruments pressures may be read with a mean error of not more than a ten-thousandth of a millimetre.—On a hitherto untried form of mounting either equatorial or azimuth, for a telescope of exceptional size, either reflector or refractor, in which telescope, observing floor and dome are combined in one,